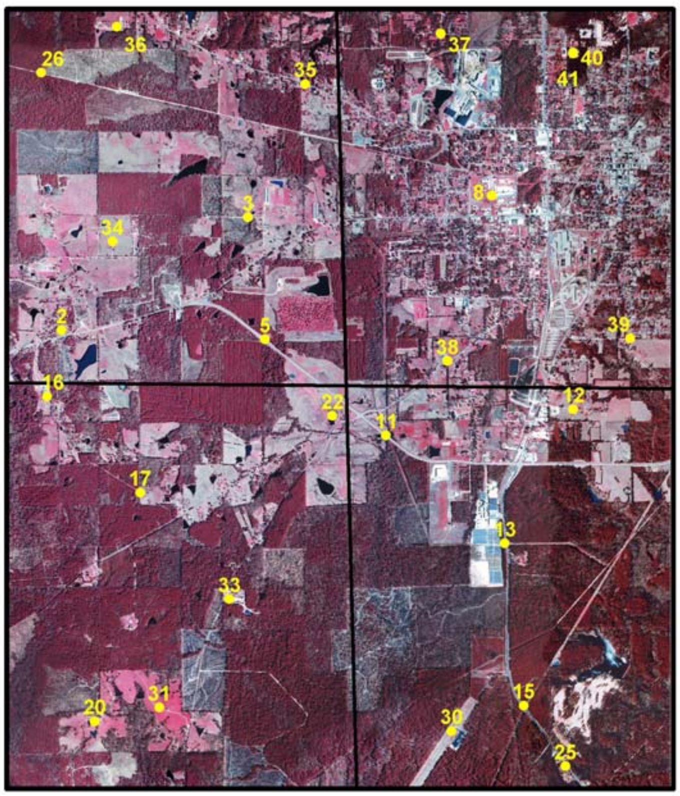
Arkansas
Warren NW Digital
Ortho Quarter Quadrangle

National Standard for Spatial Data Accuracy Report

08/20/01



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http://www.gis.state.ar.us/SGIC/ADOP/assess.htm

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Background

The Arkansas State Land Information Board (ASLIB) contracted Pixxures to produce second generation Digital Ortho Quarter Quadrangles (DOQQ's) for the State of Arkansas. The project began January 15, 2001 and was termed ADOP (Arkansas Digital Ortho Program). Through ADOP the state will receive 1-meter resolution, color contrast / balanced, seamless edge matched, feather adapted Geo-Tiff images, Mr. Sids 5:1 compressed images and standard United States Geological Survey (USGS) DOQQ's.

The project is coordinated through the State Geographic Information Office (SGIO) and funded by contributors throughout the state including: Arkansas Game and Fish Commission, Economic Development of Arkansas Fund, Benton County, Crawford County, Sebastian County, The Ross Foundation, The Timber Company, International Paper, Weyerhaeuser, U.S. Forest, Little Rock District- U.S. Army Corps of Engineers, Service and U.S. Geological Survey. The history and status of the ADOP project can be tracked via the web at: http://www.gis.state.ar.us/.

Abstract
The Federal Geographic Data Committee (FGDC) established the National Standard for Spatial Data Accuracy (NSSDA) in 1998. The NSSDA provides a "statistical and testing" methodology for reporting the accuracy of vector and raster graphics. These methodologies enable one to compare the coordinates of an independent data set to the coordinates of the test data set to determine the horizontal or vertical accuracy of the test data set. This document will examine the horizontal accuracy of a second-generation digital orthophoto quarter quadrangle (DOQQ) produced by Pixxures. The independent data set was created utilizing Global Positioning System technologies. The test data set was created by heads-up digitizing points on the second-generation DOQQ. Reporting the accuracy of spatial data following a common methodology allows end users of the spatial data to determine its usefulness.

Keywords
accuracy assessment, digital orthophoto quarter quadrangle (DOQQ), independent data set, National Standard for Spatial Data Accuracy, test data set

Definitions
Independent points (data set)- fixed positions collected utilizing GPS methodologies, creating a data set of a higher degree of accuracy than the one being tested.

Test points- positions that could be visually interpreted on the DOQQ and in the field. These positions were compiled manually utilizing heads-up digitizing methodologies.

Purpose
1. Determine the accuracy of the Warren NW DOQQ
2. Demonstrate the proper use of NSSDA reporting methodologies
3. Demonstrate not all DOQQ's are of the same accuracy
4. Determine the accuracy of a Pixxures DOQQ

Accuracy Assessment
An accuracy assessment (AA) of the second generation Warren Northwest (Geo-Tiff) DOQQ was conducted utilizing methodologies presented in the NSSDA (appendix I). The AA will provide those using the Warren NW second generation DOQQ with its known horizontal accuracy. This will insure that spatial data created utilizing the second generation DOQQ can be performed with known horizontal accuracies. This document will present the methodologies used while performing the AA on the second-generation Warren NW DOQQ.

Results
The Warren NW second generation DOQQ tested 5-meters (16-feet) horizontal accuracy at 95% confidence level.

Location

The Warren NW quarter quad (shown in red) is located in Bradley County (blue). The Warren NW quarter quadrangle is approximately eighty-nine miles south of Little Rock on interstate 30.

Figure 1

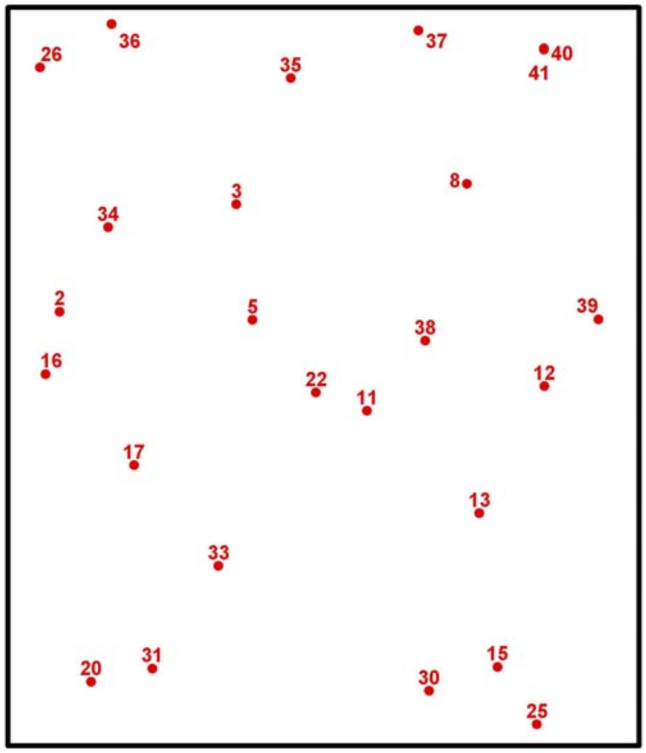
The area encompassed by the Warren NW DOQQ is characterized as both rural and urban. A number of photo interpretable land cover is present, including: hardwood, softwood, agriculture, urban and hydrologic features.

The Selection of Independent Points

The NSSDA provides guidelines for selecting independent points prior to performing fieldwork. During the pilot (Lewisville NW, May 15, 2001), it was observed that the NSSDA guidelines (appendix II) were difficult to follow due to accessibility in rural areas, and visual interpretation of the DOQQ. To this end a considerable amount of mission planning time was spent, prior to performing the fieldwork. Specific attention was given to the ability to interpret independent points and the accessibility to the predetermined sites.

Figure 2 illustrates the distribution of the independent points selected. A detailed description of each point is provided in appendix III.

Figure 2



Developing Independent and Test Datasets

Utilizing ArcView 3.1 software, and the second generation Warren NW DOQQ (Geo-Tiff), independent points were selected. Independent points that were believed to represent a strong contrast change were examined and a point was placed in the center of converging pixel change at a scale of 1:0 (Figure 3). The points manually placed on the DOQQ served as the test data set. The coordinates for the independent points were acquired utilizing GPS methodologies. (Refer to appendix IV for metadata pertaining to the GPS methodologies employed.)

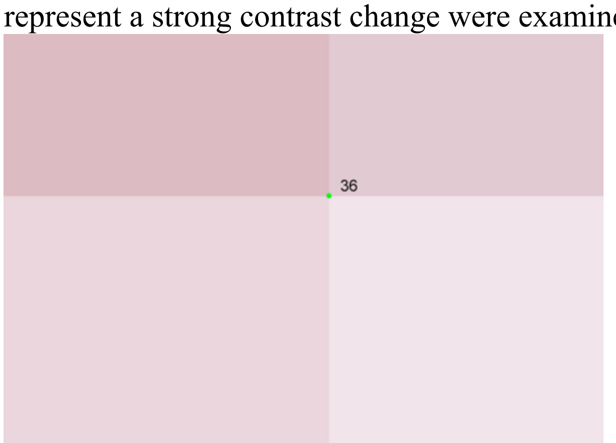


Figure 3

Collecting the coordinates for independent points in the field
A number of "pre-selected independent points" were discarded during fieldwork. These points were deemed un-interpretable in the field due to vegetation change, human impact, or accessibility. To make up the difference for the independent points discarded; independent points were added while in the field. Once all of the independent point coordinates were acquired the data was transferred from a Trimble ProXR to the Trimble Pathfinder Office Software. The independent points were then exported from the Trimble Pathfinder Software to an ArcView shapefile, and viewed in ArcView 3.1. This was done to insure an adequate number of independent points had been collected and properly distributed to perform the statistical analysis specified by the NSSDA, prior to returning to the office. (Refer to appendix V for a complete listing of resources utilized.)

Determining the Difference
In the office test points were adjusted to more precise pixel locations based on knowledge of the area obtained during fieldwork. All test point ID numbers were compared to the filename of the independent data set to insure the two data sets had been properly attributed. Coordinates for the test data set were acquired utilizing the ArcView script Add XY[1]. The coordinates obtained for the independent data set were real time differentially corrected (refer to appendix IV), and exported from Pathfinder Office into an ArcView shapefile. Using the functionality of the Pathfinder software a number of attributes were included with the shapefile. (Refer to appendix VI.)

The coordinates from the test and independent datasets were copied into a NSSDA worksheet[2]. The following information resulted, utilizing the horizontal accuracy work sheet (Table 1).

Table 1

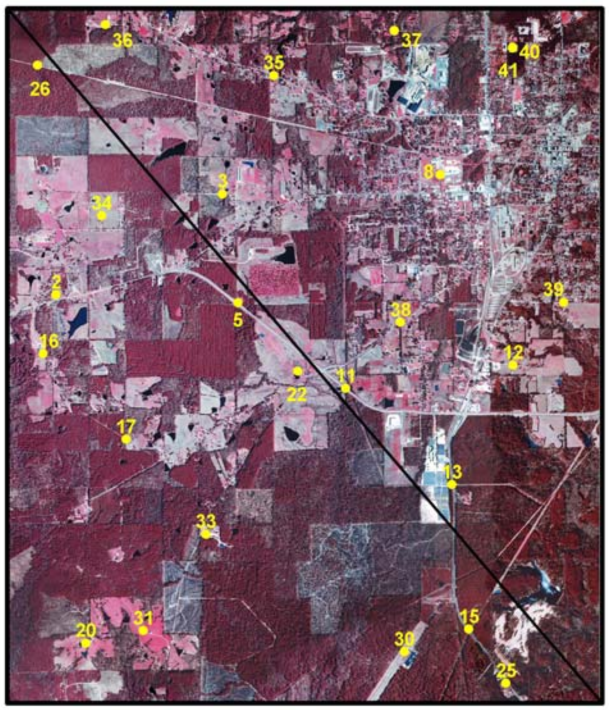
Item	**Description**
Point Description	unique id number represented in each of the data sets
X (independent)	x coordinate of point from independent data set
X (test)	x coordinate of point from test data set
Difference in X	x (independent) – x (test)
(Difference in X)^2	squared difference in x = (x (independent) – x (test))^2
Y (independent)	y coordinate of point from independent data set
Y (test)	y coordinate of point from test data set
Difference in Y	y (independent) – y (test)
(Difference in Y)^2	squared difference in y = (y (independent) – y (test))^2
(Difference in X)^2 + (Difference in Y)^2	squared difference in x plus squared difference in y equals (error radius)^2
Sum	sum of (Difference in X)^2 + (Difference in Y)^2
Average	sum divided by the number of points
Root Mean Square Error	RMSE (radial) = average $^{1/2}$
National Standard for Spatial Data Accuracy	NSSDA statistic = 1.7308* RMSE

It is important to understand the results observed from the NSSDA test are not a function of good or bad spatial data. The NSSDA is only a statistic to represent the spatial accuracy of the test data set to that of the independent data set. The NSSDA does not set a standard for what is to be considered accurate data. The end user of the spatial data should determine if the accuracy is acceptable for their project.

Analysis

Utilizing the NSSDA worksheet, the Warren NW second generation DOQQ tested 5-meters (16-feet) horizontal accuracy at 95% confidence level (appendix VII). Figure 4 shows the distribution of points across the DOQQ and along the diagonal.

Figure 4



USGS Standards for Digital Orthophotos, part 2.6 of the specifications states "… DOQ's must meet National Map Accuracy Standards (NMAS) at 1:24,000 and 1:12,000 scale respectively. The NMAS specify that 90% of the well-defined points tested must fall within 40 feet at 1:24,000 and 33.3 feet at 1:12,000 scale"[3].

The Warren NW DOQQ produced by Pixxures falls within the USGS DOQ specifications.

Conclusion

Accuracy assessments performed following the NSSDA provide the end user of the geospatial data with known accuracies that follow a common methodology. The horizontal accuracy of the Warren NW DOQQ was found to be 5-meters (16-feet) with a 95% confidence level. ***This does not imply that all second generation DOQQ's have the same horizontal accuracy.*** The control points selected and quality of elevation model (data) for the area are major contributors to the accuracy of all DOQQ's. NSSDA tests should be performed on each individual DOQQ when the spatial project requires known accuracies.

Appendix I- Selected Portion of the NSSDA (GeoSpatial Positioning Accuracy Standards Part 3)

*The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html

Federal Geographic Data Committee FGDC-STD-007.3-1998
Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy

3.2 Testing Methodology And Reporting Requirements

3.2.1 Spatial Accuracy

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points . [1] Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the 95%confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product.

3.2.2 Accuracy Test Guidelines

According to the Spatial Data Transfer Standard (SDTS) (ANSI-NCITS, 1998), accuracy testing by an independent source of higher accuracy is the preferred test for positional accuracy. Consequently, the NSSDA presents guidelines for accuracy testing by an independent source of higher accuracy. The independent source of higher accuracy shall the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.[2]

The data producer shall determine the geographic extent of testing. Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with [3] coordinates of the same points from an independent source of higher accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy.

Errors in recording or processing data, such as reversing signs or inconsistencies between the dataset and independent source of higher accuracy in coordinate reference system definition, must be corrected before computing the accuracy value.

A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level [4] allows one point to fail the threshold given in product specifications.

If fewer than twenty points can be identified for testing, use an alternative means to evaluate the accuracy of the dataset. SDTS (ANSI-NCITS, 1998) identifies these alternative methods for determining positional accuracy:

* Deductive Estimate
* Internal Evidence
* Comparison to Source

3.2.3 Accuracy Reporting

Spatial data may be compiled to comply with one accuracy value for the vertical component and another for the horizontal component. If a dataset does not contain elevation data, label for horizontal accuracy only. Conversely, when a dataset, e.g. a gridded digital elevation dataset or elevation contour dataset, does not contain well-defined points, label for vertical accuracy only.

A dataset may contain themes or geographic areas that have different accuracies. Below are guidelines for reporting accuracy of a composite dataset:

* If data of varying accuracies can be identified separately in a dataset, compute and report separate accuracy values.

* If data of varying accuracies are composited and cannot be separately identified AND the dataset is tested, report the accuracy value for the composited data.
* If a composited dataset is not tested, report the accuracy value for the least accurate dataset component.

Positional accuracy values shall be reported in ground distances. Metric units shall be used when the dataset coordinates are in meters. Feet shall be used when the dataset coordinates are in feet. The number of significant places for the accuracy value shall be equal to the number of significant places for the dataset point coordinates.

Accuracy reporting in ground distances allows users to directly compare datasets of differing scales or resolutions. A simple statement of conformance (or omission, when a map or dataset is non-conforming) is not adequate in itself. Measures based on map characteristics, such as publication scale or contour interval, are not longer adequate when data can be readily manipulated and output to any scale or to different data formats.

Report accuracy at the 95% confidence level for data *tested* for both horizontal and vertical accuracy as:

Tested ____ (meters, feet) horizontal accuracy at 95% confidence level
____ (meters, feet) vertical accuracy at 95% confidence level

Appendix II- (GeoSpatial Positioning Accuracy Standards Part 3- Appendix 3-C)

*The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html

Part 3: National Standard for Spatial Data Accuracy
Appendix 3-C (informative): Testing guidelines
Page 3-17

1. Well-Defined Points

A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points.

The selected points will differ depending on the type of dataset and output scale of the dataset. For graphic maps and vector data, suitable well-defined points represent right-angle intersections of roads, railroads, or other linear mapped features, such as canals, ditches, trails, fence lines, and pipelines. For orthoimagery, suitable well-defined points may represent features such as small isolated shrubs or bushes, in addition to right-angle intersections of linear features. For map products at scales of 1:5,000 or larger, such as engineering plats or property maps, suitable well-defined points may represent additional features such as utility access covers and intersections of sidewalks, curbs, or gutters.

2. Data acquisition for the independent source of higher accuracy

The independent source of higher accuracy shall be acquired separately from data used in the aerotriangulation solution or other production procedures. The independent source of higher accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.

Although guidelines given here are for geodetic ground surveys, the geodetic survey is only one of many possible ways to acquire data for the independent source of higher accuracy. Geodetic control surveys are designed and executed using field specifications for geodetic control surveys (Federal Geodetic Control Committee, 1984). Accuracy of geodetic control surveys is evaluated using Part 2, Standards for Geodetic Networks (Federal Geographic Data Committee, 1998). To evaluate if the accuracy of geodetic survey is sufficiently greater than the positional accuracy value given in the product specification, compare the FGCS **network accuracy** reported for the geodetic survey with the accuracy value given by the product specification for the dataset. Other possible sources for higher accuracy information are Global Positioning System (GPS) ground surveys, photogrammetric methods, and data bases of high accuracy point coordinates.

3. Check Point Location

Due to the diversity of user requirements for digital geospatial data and maps, it is not realistic to include statements in this standard that specify the spatial distribution of check points. Data and/or map producers must determine check point locations. This section provides guidelines for distributing the check point locations.

Check points may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. When data exist for only a portion of the dataset, confine test points to that area. When the distribution of error is likely to be nonrandom, it may be desirable to locate check points to correspond to the error distribution.

For a dataset covering a rectangular area that is believed to have uniform positional accuracy, check points may be distributed so that points are spaced at intervals of at least 10 percent of the diagonal distance across the dataset *and* at least 20 percent of the points are located in each quadrant of the dataset.

Appendix III- Detailed description of the independent points collected.

ID	Description
1	Discard
2	Travel north/northwest along Bradley Rd, first drive on right, where drive, road, and vegetation meet (south side of drive)
3	Turn north off of US Hwy 278 W (Bus) onto Bradley (232) Rd; travel through bend in road to travel west; point located at first drive on north side of road at the SW corner of drive, were the drive meets road gravel and vegetation
4	Discard
5	Travel NW along State Highway 4; point located at SW corner of drive where asphalt meets gravel (north/northeast side of highway)
6	Discard
7	Discard
8	Traveling north on Bragg St, point located on east side of road where "black" asphalt meets "lighter" road and vegetation
9	Discard
10	Discard
11	Travel south/southeast on State Highway 4 to first bridge; point located on NW corner of bridge (in power line view) where concrete meets asphalt and vegetation
12	Turn east onto Weir Rd. off of Main St.; point located at first drive on south side of the road and the east side of the drive where it meets the road gravel and vegetation
13	West side of Highway 15 at lumber yard, point located on the NW corner of where concrete meets gravel and vegetation
14	Discard
15	East side of Highway 15 at edge of road where power line edge meets trees and converges to a point at road
16	SE corner livestock barn off of US Highway 278
17	West side of Bradley Rd., point located where power line, road, and vegetation meet
18	Discard
19	Where logging road meets gravel road
20	SW corner of barn located at the farmland in SW corner of DOQ
21	Discard
22	SE corner of barn located off of north side of Bradley Rd.
23	Discard
24	Discard
25	SW corner of asphalt drive where asphalt meets gravel and vegetation, on Highway 15
26	North side of Bradley Rd 17, in clear-cut area where timber line meets road
30	Point located at the municipal airport on NE end of runway at the SW corner of the white block (markers/strips) near the number 21
31	Point located at farmland found in the SW quadrant of DOQ, NE side of road/gate where fence line meets road (traveling through field)
32	Discard
33	SW corner of home located on east side of Bradley Rd
34	Home found in open field along Bradley (336) Rd, point located at the SE corner of sidewalk where it meets the grass along front (south side) of house
35	East side of drive, north side of Pine St, [asphalt] road, drive, and vegetation
36	End of fence row where it meets Adams Road on the north side
37	Center of intersection at Deer Street and Pennister
38	Martin Street church, point located on right sidewalk (leading out of church) at the outside edge, where sidewalk angles toward road
39	Center of intersection at Shelby and Myrtle
40	Inside angle (SE of sidewalk) within apartment complex, east of DHS
41	Inside angel (NW of sidewalk) within apartment complex east of DHS

Appendix IV- GPS Metadata

GPS Metadata

Type of receiver	Trimble ProXR
Accuracy of receiver as stated by manufacturer	sub meter
Approximate distance from the base station used for differential correction	15.5 miles
Base station used for differential correction	Spatial Analysis Laboratory, University of Arkansas, Monticello Latitude 33 ^{o} 35 31.84178 N Longitude -91 ^{o} 48 53.43183 W Elevation 64.359 m HAE http://sal.uamont.edu/sal/pages/gps.htm
Coordinate system	Geographic (lat/long)
Datum	WGS 84
Date of collection	05/23/01
Differential correction applied	Differential Correction was used
Elevation Model	Height above Ellipsoid
Minimum number of positions for point feature	60
PDOP Mask	Maximum of 6
SNR Mask	Minimum of 6
Units of Measure	meters
Vertical accuracy as stated by manufacturer	meter

Appendix V- Resources utilized while performing the NSSDA

- Trimble Pro XR
- Dell Latitude CPI Laptop
- Hand held compass
- Arc View 3.1
- 2nd generation color infrared DOQQ of Warren NW quarter quadrangle, and surrounding DOQQ's
- Pathfinder Office software
- Tiger line files (used for orientation purposes)
- Hardcopy of the Warren NW quarter quadrangle with pre-selected points overlaid
- Approximately 30 man-hours.

Appendix VI- Attributes exported with the Independent data set

Shape	Date	Time	
File_name	Picture name	Max_pdop	
Corrected_type	Reciever Type	GPS-date	
GPS_time	Feat_name	Datafile	
Unfiltered_positions	Filtered_positions	Updated_station	
Standard deveation	GPS_height	Horizontial_Precission	
Vertical_Precission	Latitude	Longitude	
Point ID	Data_dictionary	GPS_week	GPS_second

Appendix VII- Horizontal Accuracy Worksheet Results from the NSSDA Test Performed on the Second Generation DOQQ

A Point number	C x (independent)	D x (test)	E diff in x	F $(\text{diff in x})^2$	G y (independent)	H y (test)	I diff in y	J $(\text{diff in y})^2$	K $(\text{diff in x})^2 + (\text{diff in y})^2$
2	581371.77911	581373.00006	-1.22095	1.4907189	3718158.38509	3718163.00004	-4.61495	21.2977635	22.7884824
3	583195.97863	583196.99987	-1.02124	1.04293114	3719267.11152	3719268.99976	-1.88824	3.5654503	4.608381436
5	583362.34710	583362.99991	-0.65281	0.4261609	3718070.92674	3718075.00010	-4.07336	16.5922617	17.01842258
8	585578.46486	585579.99993	-1.53507	2.35643991	3719478.07435	3719481.99992	-3.92557	15.4100998	17.76653973
11	584544.34501	584546.99997	-2.65496	7.0488126	3717132.59491	3717131.99990	0.59501	0.3540369	7.402849501
12	586374.89301	586371.99969	2.89332	8.37130062	3717386.87570	3717389.00026	-2.12456	4.51375519	12.88505582
13	585705.47440	585706.99991	-1.52551	2.32718076	3716074.47002	3716075.99982	-1.5298	2.34028804	4.667468801
15	585891.76496	585892.00019	-0.23523	0.05533315	3714486.91297	3714492.99996	-6.08699	37.0514473	37.10678042
16	581229.58151	581228.00033	1.58118	2.50013019	3717511.77459	3717514.99954	-3.22495	10.4003025	12.9004327
17	582140.45552	582141.00008	-0.54456	0.29654559	3716571.47253	3716571.00004	0.47249	0.2232468	0.519792394
20	581698.21408	581698.99982	-0.78574	0.61738735	3714332.85512	3714335.00014	-2.14502	4.6011108	5.218498149
22	584019.91511	584021.00007	-1.08496	1.1771382	3717320.93875	3717322.99987	-2.06112	4.24821565	5.425353855
25	586299.08665	586298.00046	1.08619	1.17980872	3713892.67593	3713895.99980	-3.32387	11.0481118	12.22792049
26	581172.30061	581173.00012	-0.69951	0.48931424	3720679.55837	3720683.00015	-3.44178	11.8458496	12.33516381
30	585184.87689	585186.00024	-1.12335	1.26191522	3714237.47048	3714239.99970	-2.52922	6.39695381	7.65886903
31	582329.18021	582329.02033	0.15988	0.02556161	3714468.98877	3714470.88045	-1.89168	3.57845322	3.604014836
33	583013.33912	583013.00000	0.33912	0.11500237	3715528.98334	3715530.99993	-2.01659	4.06663523	4.181637603
34	581872.42258	581873.99997	-1.57739	2.48815921	3719029.04791	3719031.99975	-2.95184	8.71335938	11.2015186
35	583757.41239	583758.00001	-0.58762	0.34529726	3720569.73772	3720572.00001	-2.26229	5.11795604	5.463253308
36	581911.45726	581911.00001	0.45725	0.20907756	3721127.62708	3721126.00003	1.62705	2.6472917	2.856369264
37	585078.29582	585080.57928	-2.28346	5.21418957	3721063.05981	3721063.28511	-0.2253	0.05076009	5.264949661
38	585144.33897	585145.99937	-1.66040	2.75692816	3717857.94612	3717860.99973	-3.05361	9.32453403	12.08146219
39	586932.48503	586931.80926	0.67577	0.45666509	3718078.56228	3718079.78329	-1.22101	1.49086542	1.947530513
40	586372.36710	586374.00007	-1.63297	2.66659102	3720877.52120	3720879.00000	-1.4788	2.18684944	4.853440461
41	586372.24757	586372.00004	0.24753	0.0612711	3720867.21120	3720869.99994	-2.78874	7.77707079	7.83834189

sum	239.8225294
average	9.592901177
RMSE	3.097240898
NSSDA	5.360704545